

# Memorandum

## Environment and Resources



**Date** April 9, 2015

**To** Kelly Meadows, Tetra Tech; Damien Houlihan, Danielle Gaito, Mark Stein, Michael Curley, EPA Region 1; Jennifer Chan, EPA Office of Wastewater Management

**From** Michael Fisher and Lisa Tarquinio

**Subject** Assessment of Affordability of Cooling Water Intake System Permit Options for Pilgrim Nuclear Plant

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This memorandum provides a summary assessment of the affordability impact of alternative cooling water intake permit options for Pilgrim nuclear plant in Plymouth, Massachusetts.

The analysis presented in this memo covers only the affordability assessment – i.e., plant-level cost and economic impact analysis – for the specified permit options. We have not completed the assessment of electricity rate impacts or potential reliability impacts. For now, we held off on this analysis for two reasons:

1. After completing the affordability analysis described in this memo, we have essentially exhausted the level of effort (LOE) specified in the task request. In our review and data and possible approaches for the rate and reliability impact assessments, we concluded that we could not complete these assessments with the remaining LOE.
2. Based on the analysis and findings presented in this memo, we also thought it would be possible that EPA Region 1 would decide not to go forward with the rate and reliability impact assessments.

The final section of the memo, *Section 4: Potential Rate and Reliability Impact Assessment*, outlines our initial thoughts on approach and data sources for these analyses, if should EPA Region 1 decide to undertake them.

### 1 Overview of Affordability Analysis

For the affordability assessment, we used a plant level cost-to-revenue analysis as a measure of financial impact, and thus ability to incur the cost and operating effects of the permit options. This analysis compares the annualized after-tax cash flow impact of each permit option to estimated plant-level revenue, based on wholesale generation segment revenue data from Entergy's financial reports and Energy Information Administration (EIA) data on Pilgrim plant electricity generation for recent years. The following *Section 2: Key Data and Assumptions for the Affordability Analysis*, provides additional detail on key data sources and assumptions for the analysis.

In this assessment, we found quite substantial economic/financial impacts at the plant level, as reported in the tables in *Section 3: Analysis Results*.

### 2 Key Data and Assumptions for the Affordability Analysis

We took much of the financial data for this analysis from Entergy's Form 10-K reports for the past several years. We used financial data specifically for the Entergy Wholesale Commodities (WEC) business unit, for which financial information is provided as a separately reporting business segment in Entergy's financial statements. This segment holds Entergy's non-regulated electric power business, which comprises 6 nuclear generating plants operating in deregulated markets; 5 (including the Pilgrim

plant) are located in the Northeast Power Coordinating Council (NPCC) region (New England and New York). Because the WEC segment plants operate primarily in the NPCC region, which is the relevant electric power market for the Pilgrim plant, we judged this data as providing a reasonable basis for the revenue, price and operating income information used in this analysis. We also used certain information presented in Entergy's reports on the cost of financial capital for this business segment. Because (1) the WEC segment represents only about 20 percent of Entergy's total revenue and (2) the remaining 80 percent of Entergy's revenue is derived from rate-regulated business, we judged that total company information for cost of financial capital might not be reasonably representative of the financial and risk circumstances applying to the non-regulated business segment. Fortunately, the WEC segment reports contained cost of capital information, which could be used in this analysis.<sup>1</sup>

For this memorandum, we analyzed all of the permit options specified in the file CCC Cost Estimates\_March 2015 SOW.xlsx file received from EPA Region 1 on March 25, 2015. We made certain assumptions – e.g., regarding start and completion of construction – in analyzing these permit options. *Table 2-1*, below, summarizes these permit option specifications and certain associated calculation values (e.g., cost of construction downtime outage, cost of seasonal shutdown).

<b>Table 2-1: Analysis Case Specifications – All dollar values on private, pre-tax basis, at indicated years; all values in \$000, except for electricity sales prices, in \$/MWh</b>					
<b>Permit Option</b>	<b>Option 1 Est. 1</b>	<b>Option 1 Est. 2</b>	<b>Option 2/3 Est. 1</b>	<b>Option 2/3 Est. 2</b>	<b>Option 2/3 Est. 3</b>
<b>Capital Cost of Technology as of 2014</b>	\$1,000,000	\$820,781	\$507,777	\$249,721	\$499,443
<b>Construction Duration (months)</b>	24	24	24	24	24
<b>First Year of Technology Operation</b>	2018	2018	2018	2018	2018
<b>Construction Outage Cost</b>					
Outage Net Duration (weeks)	75	75	9	9	9
Lost Energy Sales (MWh)	7,719,836	7,719,836	926,380	926,380	926,380
Price for Lost Sales (\$/MWh at 2017)	\$50	\$50	\$50	\$50	\$50
Construction Outage Cost	\$385,992	\$385,992	\$46,319	\$46,319	\$46,319
<b>Summer Shutdown Cost</b>					
Lost Energy Sales (MWh)	0	0	1,410,499	1,410,499	1,410,499
Price for Lost Sales (\$/MWh in 2018, first operating year)	\$51	\$51	\$51	\$51	\$51
Summer Shutdown Cost in 2018	-	-	\$71,935	\$71,935	\$71,935
<b>O&amp;M Expense as of 2014</b>	\$445	\$445	\$445	\$445	\$445
<b>Energy-Related Operating Effects</b>					
Auxiliary energy requirement (MW)	20	20	20	20	20
Thermal Efficiency Loss (%)	2.5%	2.5%	2.5%	2.5%	2.5%
Total Energy-Related Effect - Revenue Loss in 2018	\$15,438	\$15,438	\$11,549	\$11,549	\$11,549
<b>Technology Operating Life and Resulting Analysis Period (years)</b>					
<b>Unconstrained by Nuclear License</b>	30	30	30	30	30
<b>Constrained by Nuclear License</b>	15	15	15	15	15

<sup>1</sup> This information was reported as part of an asset impairment analysis stemming from the closure and write-down of business assets for the Vermont Yankee plant.

Other key assumptions and/or data sources are summarized below:

- Annual generation and seasonal generation (used for estimating revenue loss from seasonal shutdown) from EIA 920 2013 and 2012.
- Capital and O&M costs taken from CCC Cost Estimates\_March 2015 SOW.xlsx
- All cost values in this analysis are escalated to the first occurrence year using the Engineering News Record Construction Cost Index (CCI, historical index change to most recent reporting period and most recent 10-year average of index change for subsequent years) and then adjusted forward on the basis of expected nominal change (most recent 10-year average of CCI change for subsequent years).
- Analysis is performed in nominal dollars – i.e., using actual prices and costs estimated to occur in a given year – based on cost and price adjustment indexes as described here.
- Auxiliary energy requirement load (20 MW) taken from ENERCON CWA §308 response document page 30
- Assumed thermal efficiency loss of 2.5 percent of generating capacity based on 316(b) final rule analyses
- Construction outage duration based on the average of EPA Region 1 low and high values.
- Construction outage is assumed to occur during nuclear refueling periods, which occur every other year for the Pilgrim plant.
- Nuclear refueling duration is assumed to be 5 weeks, based on the average of refueling outage periods for 2009, 2011, and 2013.
- Net construction outage is calculated as gross construction outage weeks less nuclear refueling outage weeks.
- Weighted average, after-tax cost of capital of 7.5 percent, from Vermont Yankee impaired asset value analysis in the 2014 Form 10K, is used in present value and annualized cost calculations.
- Electricity price per MWh for 2015 through 2019 is taken from the 2014 Form 10K for contracted sales from the WEC business unit.
- After 2019, electricity prices are assumed to change per EIA 2014 Annual Energy Outlook projections for NPCC New England.
- These electricity price values are used to calculate lost revenue during construction outage, and the ongoing loss in revenue from energy effects and seasonal capacity shutdown for Option 2/3.
- Energy-related operating effects – auxiliary energy requirement and thermal efficiency loss – are valued on the basis of lost revenue. The plant is assumed to be running at full output during periods of operation and cannot increase energy output to offset these losses.
- Two analysis cases presented:
  - Assuming full 30-year operating life of compliance technology
  - Assuming plant and technology operation constrained to remaining years of nuclear operating license – through 2032, or 15 years, assuming technology operation year of 2018. Notably, the company identifies the remaining life of the nuclear license as a material business factor in its operations.

### **3 Analysis Results**

The tables on the following pages summarize the principal results from this analysis.

<b>Table 3-1: Present Value and Annualized Cost at 7.5%, over 30-year technology operating life (\$000, all present values as of 2014)</b>					
<b>Present Value as of 2014</b>	<b>Compliance Technology Option</b>				
	<b>Option 1 Est. 1</b>	<b>Option 1 Est. 2</b>	<b>Option 2/3 Est. 1</b>	<b>Option 2/3 Est. 2</b>	<b>Option 2/3 Est. 3</b>
<b>Initial Outlays and Depreciation</b>					
Capital Outlay	\$904,528.5	\$742,419.5	\$459,299.0	\$225,880.0	\$451,760.0
Depreciation Tax Benefit	-\$185,297.3	-\$152,088.5	-\$94,089.8	-\$46,272.7	-\$92,545.4
<b>Construction Outage Expense</b>					
Cost: Income Loss Basis	\$310,708.2	\$310,708.2	\$37,285.0	\$37,285.0	\$37,285.0
Tax Adjustment	-\$136,338.7	-\$136,338.7	-\$16,360.6	-\$16,360.6	-\$16,360.6
Net Cost, Construction Outage	\$174,369.4	\$174,369.4	\$20,924.3	\$20,924.3	\$20,924.3
<b>Total Initial Cost, Net Tax</b>	<b>\$893,600.6</b>	<b>\$764,700.5</b>	<b>\$386,133.6</b>	<b>\$200,531.7</b>	<b>\$380,139.0</b>
<b>Annual Expenses and Operating Effects</b>					
Summer Shutdown Cost	\$0.0	\$0.0	\$1,255,062.6	\$1,255,062.6	\$1,255,062.6
Tax Adjustment	\$0.0	\$0.0	-\$550,721.5	-\$550,721.5	-\$550,721.5
Net Cost, Summer Shutdown	\$0.0	\$0.0	\$704,341.1	\$704,341.1	\$704,341.1
Operating and Maintenance Expense Cost	\$6,740.1	\$6,740.1	\$6,740.1	\$6,740.1	\$6,740.1
Tax Adjustment	-\$2,957.5	-\$2,957.5	-\$2,957.5	-\$2,957.5	-\$2,957.5
Net Cost, O&M Expense	\$3,782.5	\$3,782.5	\$3,782.5	\$3,782.5	\$3,782.5
<b>Total Energy-Related Effect</b>					
Cost: Revenue Loss Basis	\$269,340.2	\$269,340.2	\$201,498.2	\$201,498.2	\$201,498.2
Tax Adjustment	-\$118,186.5	-\$118,186.5	-\$88,417.4	-\$88,417.4	-\$88,417.4
Net Cost, Total Energy-Related Effect - Revenue	\$151,153.7	\$151,153.7	\$113,080.8	\$113,080.8	\$113,080.8
<b>Total Annual Cost/(Gain), After-Tax</b>	<b>\$154,936.2</b>	<b>\$154,936.2</b>	<b>\$821,204.4</b>	<b>\$821,204.4</b>	<b>\$821,204.4</b>
<b>Total After-Tax Cash Flow Cost/(Gain), Present Value at 2014, using 7.5% discount rate</b>	<b>\$1,048,536.8</b>	<b>\$919,636.7</b>	<b>\$1,207,338.0</b>	<b>\$1,021,736.1</b>	<b>\$1,201,343.4</b>
<b>Annual Equivalent Cost at 7.5% over 30 years</b>	<b>\$88,780.9</b>	<b>\$77,866.8</b>	<b>\$102,226.8</b>	<b>\$86,511.7</b>	<b>\$101,719.2</b>

**Table 3-2: Present Value and Annualized Cost at 7.5%, over 15-year remaining life of nuclear operating license (\$000, all present values as of 2014)**

Present Value as of 2014	Permit Option				
	Option 1 Est. 1	Option 1 Est. 2	Option 2/3 Est. 1	Option 2/3 Est. 2	Option 2/3 Est. 3
<b>Initial Outlays and Depreciation</b>					
Capital Outlay	\$904,528.5	\$742,419.5	\$459,299.0	\$225,880.0	\$451,760.0
Depreciation Tax Benefit	-\$191,316.3	-\$157,028.7	-\$97,146.1	-\$47,775.8	-\$95,551.5
<b>Construction Outage Expense</b>					
Cost: Income Loss Basis	\$310,708.2	\$310,708.2	\$37,285.0	\$37,285.0	\$37,285.0
Tax Adjustment	-\$136,338.7	-\$136,338.7	-\$16,360.6	-\$16,360.6	-\$16,360.6
Net Cost, Construction Outage	\$174,369.4	\$174,369.4	\$20,924.3	\$20,924.3	\$20,924.3
<b>Total Initial Cost, Net Tax</b>	<b>\$887,581.6</b>	<b>\$759,760.2</b>	<b>\$383,077.2</b>	<b>\$199,028.6</b>	<b>\$377,132.8</b>
<b>Annual Expenses and Operating Effects</b>					
Summer Shutdown Cost	\$0.0	\$0.0	\$786,197.1	\$786,197.1	\$786,197.1
Tax Adjustment	\$0.0	\$0.0	-\$344,983.3	-\$344,983.3	-\$344,983.3
Net Cost, Construction Outage	\$0.0	\$0.0	\$441,213.8	\$441,213.8	\$441,213.8
Operating and Maintenance Expense Cost	\$4,356.8	\$4,356.8	\$4,356.8	\$4,356.8	\$4,356.8
Tax Adjustment	-\$1,911.8	-\$1,911.8	-\$1,911.8	-\$1,911.8	-\$1,911.8
Net Cost, O&M Expense	\$2,445.0	\$2,445.0	\$2,445.0	\$2,445.0	\$2,445.0
Total Energy-Related Effect					
Cost: Revenue Loss Basis	\$168,720.2	\$168,720.2	\$126,222.6	\$126,222.6	\$126,222.6
Tax Adjustment	-\$74,034.4	-\$74,034.4	-\$55,386.5	-\$55,386.5	-\$55,386.5
Net Cost, Total Energy-Related Effect - Revenue	\$94,685.8	\$94,685.8	\$70,836.1	\$70,836.1	\$70,836.1
<b>Total Annual Cost/(Gain), After-Tax</b>	<b>\$97,130.8</b>	<b>\$97,130.8</b>	<b>\$514,495.0</b>	<b>\$514,495.0</b>	<b>\$514,495.0</b>
<b>Total After-Tax Cash Flow Cost/(Gain), Present Value at 2014, using 7.5% discount rate</b>	<b>\$984,712.4</b>	<b>\$856,891.0</b>	<b>\$897,572.2</b>	<b>\$713,523.6</b>	<b>\$891,627.8</b>
<b>Annual Equivalent Cost at 7.5% over 15 years</b>	<b>\$111,555.4</b>	<b>\$97,074.8</b>	<b>\$101,683.5</b>	<b>\$80,833.1</b>	<b>\$101,010.1</b>

**Table 3-3: Cost-to-Revenue Analysis (\$000)**

	Permit Option				
	Option 1 Est. 1	Option 1 Est. 2	Option 2/3 Est. 1	Option 2/3 Est. 2	Option 2/3 Est. 3
<b><u>Analysis Period of 30 Years</u></b>					
Annualized Private Cost over 30-Year Operating Period	\$88,781	\$77,867	\$102,227	\$86,512	\$101,719
Estimated Revenue, first year of Operating Period (2018)	\$279,015	\$279,015	\$279,015	\$279,015	\$279,015
<i>Annualized Cost, as Percent of Revenue (2018)</i>	<i>31.8%</i>	<i>27.9%</i>	<i>36.6%</i>	<i>31.0%</i>	<i>36.5%</i>
Estimated Revenue, last year of Operating Period (2047)	\$1,005,999	\$1,005,999	\$1,005,999	\$1,005,999	\$1,005,999
<i>Annualized Cost, as Percent of Revenue (2047)</i>	<i>8.8%</i>	<i>7.7%</i>	<i>10.2%</i>	<i>8.6%</i>	<i>10.1%</i>
Average Revenue over 30-Year Operating Period	\$627,863	\$627,863	\$627,863	\$627,863	\$627,863
<i>Annualized Cost, as Percent of Average Revenue over 30-Year Operating Period</i>	<i>14.1%</i>	<i>12.4%</i>	<i>16.3%</i>	<i>13.8%</i>	<i>16.2%</i>
<b><u>Analysis Period of 15 Years</u></b>					
Annualized Private Cost over 15-Year Operating Period	\$111,555	\$97,075	\$101,683	\$80,833	\$101,010
Estimated Revenue, first year of Operating Period (2018)	\$279,015	\$279,015	\$279,015	\$279,015	\$279,015
<i>Annualized Cost, as Percent of Revenue (2018)</i>	<i>40.0%</i>	<i>34.8%</i>	<i>36.4%</i>	<i>29.0%</i>	<i>36.2%</i>
Estimated Revenue, last year of Operating Period (2032)	\$602,524	\$602,524	\$602,524	\$602,524	\$602,524
<i>Annualized Cost, as Percent of Revenue (2032)</i>	<i>18.5%</i>	<i>16.1%</i>	<i>16.9%</i>	<i>13.4%</i>	<i>16.8%</i>
Average Revenue over 15-Year Operating Period	\$460,139	\$460,139	\$460,139	\$460,139	\$460,139
<i>Annualized Cost, as Percent of Average Revenue over 15-Year Operating Period</i>	<i>24.2%</i>	<i>21.1%</i>	<i>22.1%</i>	<i>17.6%</i>	<i>22.0%</i>

**Discussion of findings:**

- All Permit Options and analysis cases show considerable impact on plant operating financial performance, with the economic/financial impact greater if the technology operation period is constrained to the remaining life in the nuclear operating license.
  - Cost-to-revenue percentages, on average, range from 12.4 to 16.3 percent using the 30-year analysis period and 17.6 to 24.2 percent using the 15-year analysis period (i.e., constraining the remaining life of the plant to the expiration date of its nuclear operating license).
- These cost-to-revenue values provide insight into the potential impact of the permit options on the operating financial performance and business value of the Pilgrim plant. We expect the percentage loss in business value to be greater than the loss in revenue, as business value would be based on operating cash flow, which is less than plant revenue. We could perform a rough assessment of the impact on plant business value but have not done so pending guidance from EPA Region 1.
- Depending on the particular cost estimate value, the impact of lost revenue during seasonal shutdown largely offsets the reduction in capital cost between Permit Options 1 and 2/3. For example, total present and annualized values of cost and operating effects for Permit Option 2/3, Estimate 1 costs are in fact higher than Option 1, Estimate 1 costs when using the 30-year analysis period; when using the 15-year analysis period, Permit Option 1, Estimate 1 are only 9.7 percent greater than the same values for Permit Option 2/3, Estimate 1.

## **4 Potential Rate and Reliability Impact Assessment**

Although we did not complete the rate or reliability impact assessments for this memorandum, we did consider approach and data for undertaking these analyses. We describe these below.

### **4.1 Rate Impact Assessment**

- Under Option 1 (no seasonal shutdown), we assume that there will be little effect on consumer rates, at least in the short run, because Pilgrim, like other nuclear plants, operates as a baseload generating unit. As a result, we expect that increased operating costs at Pilgrim would affect equilibrium prices in the ISO-NE competitive market only during a limited number of hours during the year, and the price effect is likely to be small during these hours.
- Under Option 2/3 (seasonal shutdown), curtailment of operations during the summer, peak demand period, is likely to have a more substantial effect on market prices. Removal of the approximately 680 MW of capacity during the high demand period could affect equilibrium prices due to the reduction in total generating supply in the ISO-NE market.
- To assess potential price effects, we could perform a similar analysis to what we undertook for Brayton Point. For that analysis, we undertook econometric analysis of the relationship between available generating capacity and competitive market prices using historical data from ISO-NE. We also looked at the effect of increased production costs on equilibrium prices. These analyses found the expected relationship between increased production costs and reduced capacity availability on prices.
- While the data are available to repeat this kind of analysis, the time required to do this substantially exceeds the level of effort currently specified for the total task. The report we prepared for this analysis (May 2002) is attached. If EPA Region 1 wants to undertake this kind of analysis, we can prepare an estimate of LOE and cost.

### **4.2 Reliability Impact Assessment**

- For the reliability assessment, we planned to review NERC reports for summer reliability and long-term reliability in New England and assess how lost capacity in the summer months for Option 2/3 would affect capacity reserve margins.
- Our preliminary research indicates limited adverse impact on reliability in the next few years; however, over time, the NERC assessment indicates declining reserve margin, with increased risk of service disruption from unplanned capacity outages. Seasonal shutdown of the Pilgrim plant would add to this risk.
- So far, we have only undertaken limited research for the reliability assessment, and will need additional level of effort to complete the task.